

## D6 Characteristics Relevant to Microbunching Studies

The D6 beamline at the AGS is potentially useful for KOPIO and MECO  $\mu$ bunching studies, particularly extinction measurements. D6 is a two stage purified beam capable of providing rates greater than  $10^4 \bar{p}/10^{12} p$  incident on a 9 cm long target with an antiproton/ $(\pi + \mu + e)$  ratio of 40:1 up to 1.8 GeV/c [1].

Two stage separation greatly reduces beam halo, particularly from secondary particles whose trajectories do not originate at the production target, e.g. decay muons. Adjustable collimators minimize the unwanted beam particles reaching the second mass slit. Most important, the beam optics have been corrected to third order by means of octupole magnets, in addition to sextapoles, thereby greatly reducing the tails of beam distributions yielding improved particle separation at the mass slits and smaller beam spots.

In addition to the high purity, time of flight,  $dE/dx$  and possibly a calorimeter module behind the final focus telescope to detect  $\bar{p}p$  annihilation would good assure particle identification. It is also possible to purify a beam of secondary protons originating in the production target which would be some  $10^4$  times as intense as the antiproton beam. Although the inherent purity should be correspondingly greater, an intensity reduction would be required to obtain reasonable counting rates. Preferably, this would be achieved by reducing the primary proton beam intensity below  $10^{11}/\text{spill}$ . An additional reduction might be accomplished by reducing the momentum spread of the secondary beam as well as by means of the angular aperture defining four-jaw collimator between the second D6 quadrupole, D6Q2, and the first sextupole, D6S1. If protons were to be used, substituting a short production target, e.g. 1-2 mm for the existing 9 cm one, would be the best intensity reduction method, since it would reduce the depth of focus effect thereby yielding better images at the mass slits for greater purity. It would also minimize the target length contribution to the measured pulse lengths in the time of flight counters which would be  $\Delta t = (L/c)(1/\beta_s - 1/\beta_p) = 60$  ps where L is the target length and  $\beta_s$  and  $\beta_p$  represent  $v/c$  for the primary and secondary particles, respectively.

**TABLE I. D6 Beamline Parameters [1]**

Momentum	1.0 GeV/c	1.4 GeV/c
$\bar{p}/10^{12} p$	$0.25 \times 10^4$	$1.5 \times 10^4$
$(\pi + \mu + e)/\bar{p}$	0.15	0.025
$\Delta\beta$ ( $\Delta p/p = 5\%$ )	0.01710	0.012898
$\Delta t = (L/c)\Delta(1/\beta)$	3.31 ns	2.55 ns

Table I compares antiproton parameters at 1.0 GeV/c and 1.4 GeV/c in the D6 line as given by Pile et al. [1]. The greater  $\bar{p}$  flux and purity at the higher momentum indicate that it is desirable to run at the highest momentum the separators will allow. The time spread in the arrival time of antiproton bunches produced in the production target due to the spread in  $\beta_s$  resulting from the nominal 5% momentum spread of the beam is given in the last two lines of the table. The nominal momentum spread,  $\Delta p/p = .05$ , leads to a spread,  $\Delta\beta$ , of 1.7% at 1 GeV/c and 1.3% at 1.4 GeV/c resulting in timing spreads of several nanoseconds for the 31 m flight path from the production target to a TOF counter at the final focus. The momentum spread could be reduced by means of the momentum collimator to 0.5% which would result in timing spreads comparable to the  $\mu$ bunch widths of interest and comparable to the resolution of the TOF counters. The momentum definition may degrade for very small  $\Delta p/p$ . The upstream TOF counter is at approximately half the distance from the target but downstream of the momentum jaws. Comparison of the time spreads in the two TOF counters would allow an extrapolation back to the production target if the inherent resolution of the two detectors were sufficiently alike. However, the beam has undergone one stage of purification first TOF counter and the momentum distributions are sensitive to the mass slit positions so it would be necessary to investigate this effect which would be further complicated by the greater background in the upstream counter. An additional contribution to the measured pulse width will arise from variations in particle trajectories in traversing the beam line, mainly due to different sagittas in the dipole magnets depending on particle momentum and and phase space location. These pulse width contributions haven't been calculated but are much smaller than the spread in  $\Delta\beta$  arising from the finite momentum spread of the secondary beam.

The D6 Beamline has the potential for obtaining sensitive measurements of  $\mu$ bunching extinction. Bunch width measurements would be degraded by the finite momentum acceptance of the beam, the production target length and sagitta variations. Using a beam of purified protons with a 1 mm target length, and measuring the variation of pulse width with momentum spread and other collimators might allow a crude estimate of the primary proton  $\mu$ bunch

width.

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[1] P. Pile *et al.*, NIM A**321**, 48 (1992).